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COHERENCY EFFECTS ON RETINAL NEURAL PROCESSES (ERG) OF PSEUDEMY--ETC(U)
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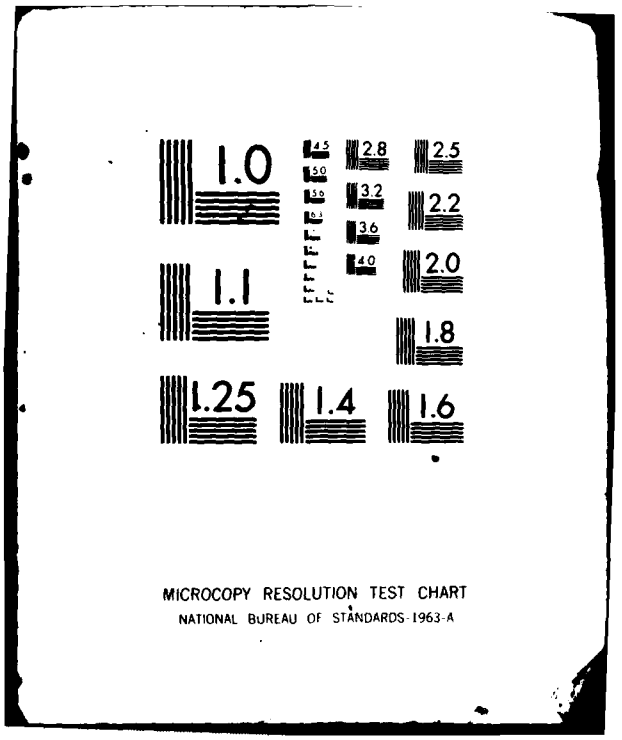
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Prolonged exposure to coherent 620 nm light was shown to be more effective than equivalent incoherent exposure in affecting the ERG spectral sensitivity of Pseudemys. Such effects may be mediated in part through lateral connections between long- and short-wavelength cone systems. Elimination of perceptible speckle attenuated coherent effects, suggesting a unique interaction of laser speckle with retinal processes. Explanation of these coherency effects involve disruption of normal neural retinal channels resulting from prolonged continuous laser exposure.

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COHERENCY EFFECTS ON RETINAL NEURAL PROCESSES OF PSEUDEMYS

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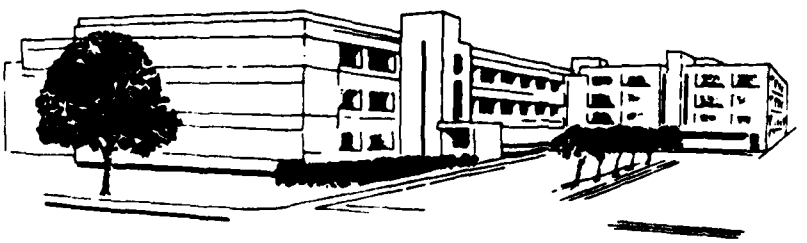
DECEMBER 1981



LETTERMAN ARMY INSTITUTE OF RESEARCH PRESIDIO OF SAN FRANCISCO CALIFORNIA 94129

Coherency Effects on Retinal Neural Processes of Pseudemys
--Zwick and Jenkins

In conducting the research described in this report, the investigation adhered to the "Guide for the Care and Use of Laboratory Animals," as promulgated by the Committee on Revision of the Guide for Laboratory Animal Facilities and Care, Institute of Laboratory Animal Resources, National Research Council.

This material has been reviewed by Letterman Army Institute of Research and there is no objection to its presentation and/or publication. The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense. *(AR 360-5)*

John W. Marshall 27 Dec 1991
(Signature and date)

COHERENCY EFFECTS ON RETINAL NEURAL PROCESSES OF PSEUDEMYS

In a preceding paper (1), we described prolonged effects of coherent light on the spectral sensitivity of the rhesus that suggest alteration of photoreceptor systems, and possible alteration of the interrelationships between such systems. These effects may be unique to the coherency characteristics of laser sources, as they have been obtained at retinal irradiance levels 1000 times lower than those employed in comparable experiments with monochromatic incoherent light (2). In more recent work (3), using electroretinographic (ERG) measurements of spectral sensitivity, we have determined that these effects have origin in the retina. In this study, we have explored the notion that laser light is in fact more effective in altering retinal neural processes as measured by ERG spectral sensitivity in Pseudemys. This species was used because it is an animal which has eyes rich in cones as well as many synaptic retinal interrelationships (4). Our primate behavioral studies (1, 3) as well as other morphological retinal studies (5-7) suggest that cone photoreceptors may be more susceptible to coherent light than are rods, and that synaptic relationships may be either directly or indirectly altered in such effects.

METHOD

The optical and recording apparatus for measuring ERG spectral sensitivity in Pseudemys has been described previously (8). The major modification in these experiments involved the background channel. The test channel subtended 42 degrees and was collinear with the background channel for all conditions. The three sources were equated in areal subtense, peak wavelength, and retinal irradiance. The peak wavelength of all three sources was 620 nm. A dye laser system was used to deliver the 620 nm coherent light. A tungsten coil filament source with a 620 nm interference filter (half-maximum bandwidth of 10 nm) provided the incoherent source.

Coherent light was time-averaged by successively diffusing it through a vibrating and stationary diffuser (9). This procedure perceptibly eliminates the laser speckle by averaging, but does not eliminate speckle for the instantaneous case. Maximal quantal retinal irradiance for all three sources was 10^{15} quanta/s/cm^2.

RESULTS

Mean chromatically adapted spectral sensitivity functions measured after 1-h adaptation to either 620 nm coherent or 620 nm incoherent backgrounds at 10^{15} quanta/s/cm^2 are shown in Figure 1(a). For the incoherent background, three well-defined peaks in the short-, intermediate- and long-wavelength regions are obvious, but

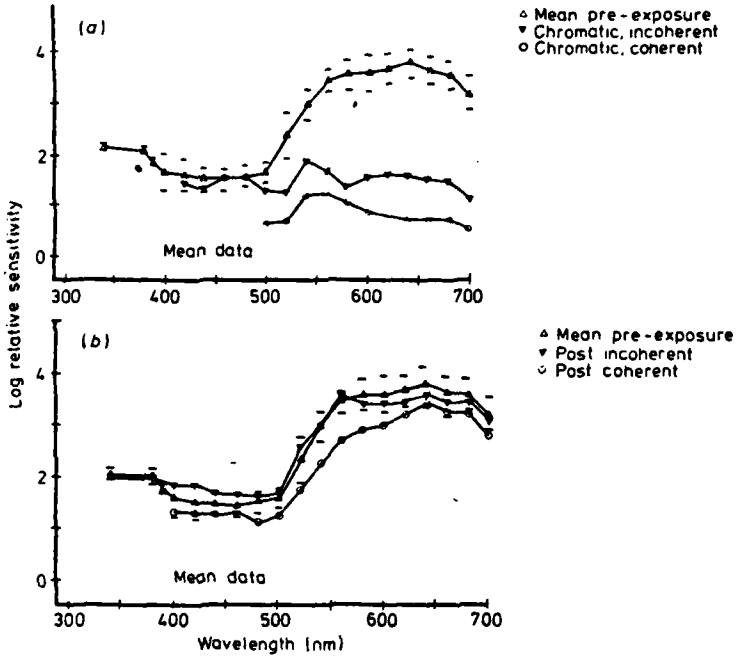


Figure 1. (*a*) Comparative effects of prolonged exposure (60 min) to either 620 nm coherent or 620 nm incoherent background at a quantal retinal irradiance of 10^{15} quanta/s/cm^2. Coherently adapted functions measured at the end of 60 min lack a peak in the short end of the spectrum relative to the incoherently adapted function. Coherent background also is more effective than the incoherent background in suppressing sensitivity across the spectrum. (*b*) Post-exposure effects for the incoherent background was minimal, ter ding to show some change in the long-wavelength region but within variability limits at these wavelengths. More significant depressions in sensitivity across much of the spectrum were obtained following coherent exposure. Little evidence of recovery was obtained in post-exposure measurements made several hours after exposure. Animals retested several weeks after exposure showed no evidence of recovery.

after 1-h exposure to the 620 nm coherent background, the peak in the short- and long-wavelength regions are gone, leaving only the one in the intermediate spectral region. The loss of the short-wavelength peak was progressive with time, being obtainable at 15 min of exposure, but no longer at about 45 min of continuous exposure. For 1-h exposures at lower coherent background retinal irradiance levels (10^{14} quanta/s/cm^2), measurements of the chromatically adapted function down to 420 nm were obtained with no evidence of a peak in this region. In Figure 1(b), post-exposure spectral sensitivity is compared with the mean pre-exposure functions shown in Figure 1(a). Although some depression in sensitivity above 560 nm is observed variability in sensitivity is within normal variability for this spectral region. Post-exposure change in spectral sensitivity for coherent exposure was permanently depressed throughout most of the spectrum, although shifts in peak spectral sensitivity were typically not evident.

In Figure 2(a), we have plotted for one animal the log relative sensitivity of a test at 640 nm as a function of background level. As the background level was decreased over 6 log unit range (10^{15}-10^{9} quanta/s/cm^2), sensitivity for both coherent and incoherent backgrounds increased. Sensitivity for the coherent background condition remained, over this range of background quantal irradiances, at least 0.6 log units less than that with the incoherent background. Each point represents a 2-min background exposure, and under these conditions no permanent shifts in baseline were obtainable. Similar relationships were found for other wavelengths through the spectrum.

In Figure 2(b) the chromatic and post-exposure spectral sensitivity functions are shown for our time-averaged input. Time-averaging the coherent source does not suppress the short-wavelength peak of the 1-h chromatically adapted curve, nor does it seem to eliminate the long-wavelength peak of this function. Post-exposure loss in sensitivity, however, is more similar to coherent exposure than incoherent exposure.

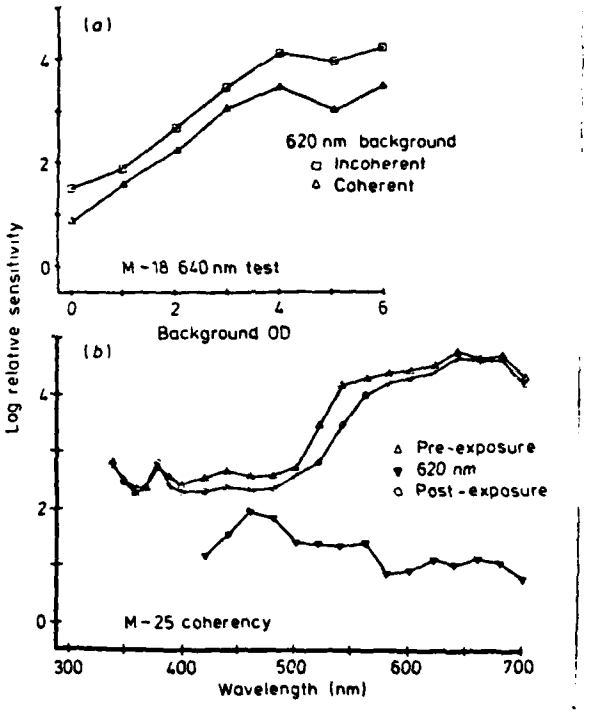


Figure 2. (*a*) Comparison of transient effects of coherent against incoherent background exposure. As background optical density is increased (intensity decreased), log relative sensitivity to a 640 nm test increases. The coherent background over a 6 log unit range is more effective in suppressing sensitivity at 640 nm than is the incoherent background, by at least 0·6 log units. (*b*) The effect of time-averaging the coherency of the laser source on both the chromatically adapted spectral sensitivity and the post-exposure spectral sensitivity is shown. Time-averaging does not eliminate the peak in the short-wavelength region of the spectrum for the chromatically adapted function, although some residual post-exposure effect on spectral sensitivity is apparent.

DISCUSSION

In this study, we have shown that laser light is more effective in producing permanent alteration ot retinal visual cone processes than filtered incoherent light. It is also obvious that for transient change, coherent light is at least 0.6 log units more effective in reducing senitivity than comparable incoherent light. Our time-averaged exposure further suggests that the speckle pattern is a significant factor in the production of these effects. Although we have not actually measured the speckle pattern at the retinal interface, data suggest that fine spatial frequencies characteristic of speckle are imaged at the retinal surface (10). These "speckles" (4-5 um in diameter) are infrequent and could be of high peak irradiance (11). It is also evident from these data that the permanent alteration of the long-wavelength photoreceptor system was accompanied by change in the short-wavelength region as well. This result suggest that we have altered, through the long-wavelength cone system, the interaction of the long- and short-wavelength systems. Such interactions in the turtle retina have been recently demonstrated by intracellular recording techniques in various lateral cell connections of this retina (4). We have obtained similar effects with higher-intensity, briefer exposure coherent light (8). But we are unaware of any similar permanent effects produced with incoherent filtered light. In our experiment, minimal effects were observed for filtered incoherent light in the long-wavelength region only, and such effects were well within the noise level of cur mean curve.

In this experiment, we made no attempt to differentiate the contribution of spectral compression yet we point out that the spectral bandwidth of our source was less than 0.05 nm which resulted in a significant spectral compression of photons at 620 nm. This characteristic is related to the coherency of laser sources and may contribute to our observed effects.

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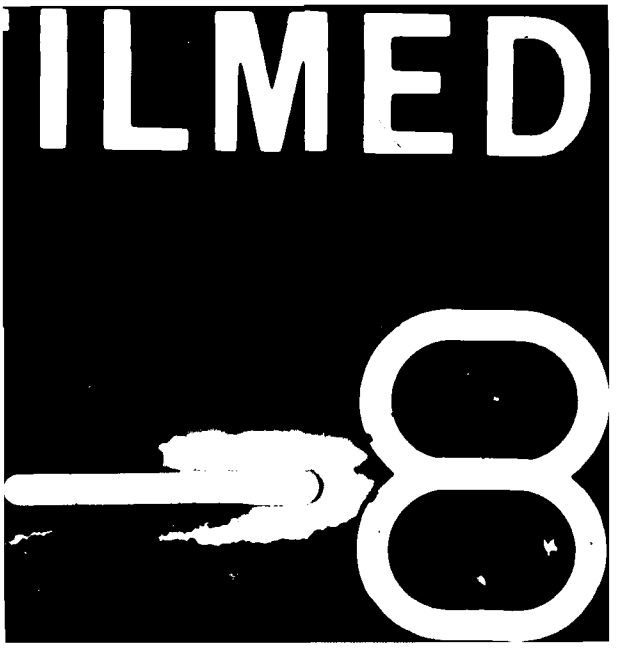
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